3.0 PREPARING FOR THE INSPECTION

3.1 INSPECTION TEAM

The required expertise of the inspector or inspection team depends on the type of inspection being performed, the type of dam, and the site conditions. The inspection personnel should be familiar with dam design, the causes of dam failures, and the telltale signs which identify problems or potential concerns. Following the visual inspection, the team members should compare their individual assessments of observed conditions and compile a single composite report.

Table 3-1
Recommended Inspection Team

Formal Technical Inspection

Lead Inspector – registered professional engineer
Assistant Inspector(s) – other professionals as needed based on type of dam and appurtenant works
Dam Owner or representative

Maintenance Inspection

Dam Maintenance Personnel - may be accompanied by a qualified dam safety professional

Informal Inspection

Dam Owner or Maintenance Personnel

Special Inspection

Dam Owner or Maintenance Personnel -should be accompanied by engineer or other professional

Dam inspectors are responsible for the safety of life and property, so they need to recognize when their expertise is inadequate. The Association of State Dam Safety Officials (http://www.damsafety.org/) and the United States Department of the Interior, Bureau of Reclamation (http://www.usbr.gov/) are two organizations that provide specific training and information that can benefit dam safety inspectors. The Bureau of Reclamation offers an excellent workshop entitled “Seminar on Safety Evaluation of Existing Dams” that provides specific inspection training for engineers, technicians, maintenance personnel, and administrators responsible for dams.

Inspection teams for a formal technical inspection should include a qualified dam safety professional, experienced in dams, as the lead inspector. Necessary team size and member expertise will vary depending upon the type of dam, and the condition of the dam or types of problems that may be present. A formal technical inspection of a dam and its appurtenances requires study, investigation, and analyses of many diverse, individual subjects and conditions, together with evaluations of their interrelationships. Accordingly, this kind of inspection requires skilled specialists with expertise that is pertinent to the dam conditions, and individuals with the broadest possible experience in all phases of dam design and construction engineering for overall review. Inspecting personnel may include individuals who are civil engineers, geotechnical engineers, hydrologists, geologists, structural engineers, engineering technicians, dam operators or tenders, and other specialists, depending on the components of the dam to be inspected. The lead inspector may perform the visual inspection alone if he/she has a broad-based, educational and technical experience with dams and if the dam does not have complex features or severe problems. On larger, complex dams it is likely that no one individual will have all the necessary expertise that is required, and a team inspection will be needed. Larger organizations may be fortunate enough to have staff that includes mechanical engineers, hydrologists, electrical engineers, geotechnical

engineers, and other specialists available to evaluate specific features of a dam. Inspecting personnel, regardless of their field of expertise, need to have knowledge in the design, analyses, construction, and operation of dams. The dam owner or his representative should always be present during a formal technical inspection to learn as much as possible about the dam and potential problems.

A maintenance inspection is typically performed by the person(s) assigned responsibility for the operation or maintenance of the dam and its appurtenant works. This person is often referred to as the dam operator or dam tender. The person assigned this responsibility should be familiar with the dam and should possess sufficient knowledge to make accurate assessment of the dam's condition. An engineer or other qualified dam safety professional may accompany the dam operator or tender during a maintenance inspection, but generally does not.

The dam owner, dam operator, or dam tender typically performs informal inspections and special inspections. Again, an engineer or other qualified dam safety professional may be required to assist in a special inspection depending on the specific situation.

The dam inspector(s) should be thorough and organized. In order to readily identify trends, it is necessary to maintain records of performance in an orderly way. Where instrumentation and seepage measurements are available, the inspector should evaluate these records at regular intervals and in a form that makes them easily interpreted. Likewise, observations made during field examinations should be recorded and maintained in the project file in such a way that trends can be visualized readily. Specific recommendations for recording and maintaining data and information appear in other chapters of this manual. If the inspector is unable to interpret or evaluate observed conditions, he/she should seek the advice of a more qualified expert.

There may be times when specialists must apply scientific and engineering knowledge and experience to a wide range of tasks during a dam inspection. These tasks may include interpretation of the geologic structure of dam sites, appraising the engineering properties of the foundation and embankment, predicting and analyzing seepage, calculating and analyzing stresses and stability of embankments and appurtenant structures, evaluating the runoff from watersheds, estimating the capacity and flow in spillways and outfalls, evaluating the mechanical and electrical equipment if present, and analyzing instrumentation and other monitoring data. The proper performance of these tasks usually requires qualified individuals such as civil engineers, soils or geotechnical engineers, engineering geologists, structural engineers, hydraulic engineers, and hydrologists. Occasionally there may be a need for the services of a mechanical engineer, an electrical engineer, or a seismologist. The assistance of engineering and geological technicians, surveyors, and laboratory technicians may also be required. A final coordinated evaluation is then made by a senior individual broadly experienced in all aspects of dam engineering, especially design. This individual is usually a civil engineer, but can also be a soils or geotechnical engineer if the dam is an embankment type.

Highly specialized services may also be required for some dams. These services may include underwater visual inspections, televised conduit inspections, or geophysical investigations. These services are readily available through specialized firms and will usually require advance notification and contractual arrangements. Underwater divers will need to have sufficient details of the project to plan safety and procedural details of the visual inspection. Televised conduit inspection may be required when conduit diameters are small or when direct access is not possible or feasible. Drilling or other geophysical services may be required if additional subsurface information is needed.

The field examination will normally consist of interviews with the owner or operating personnel, a visual inspection of the dam and all appurtenant structures, and observation of the watershed and downstream areas. The manner in which the visual inspection proceeds will depend on the site and type of inspection being made. Performance of the visual inspection will be influenced by weather, ground cover, condition of the structure, personal safety considerations, purpose of the inspection, operational considerations, and even the inspection team's level of experience. The visual inspection team should anticipate these conditions to ensure that proper equipment, clothing, and safety items are on hand. The individual inspector should consider situations when additional personnel will be required to properly conduct the visual inspection and to assure safety. Planning ahead for such contingencies may eliminate the need for a return trip.

3.2 REVIEW OF PROJECT RECORDS

3.2.1 Overview

Proper preparation is important for safety inspections of all types. The project files should be reviewed as the initial step in every dam safety inspection. The extent of the review depends on the type of inspection and how familiar the inspector is with the dam. A complete dam project file should contain four general types of information that constitute the dam information database: (1) background information, (2) design information, (3) construction records, and (4) operation performance records. This information should be reviewed by and be familiar to the inspecting personnel. A checklist of items to be reviewed before the inspection is helpful and will ensure that important documents are not overlooked (see Tables 3-2 and 3-4).

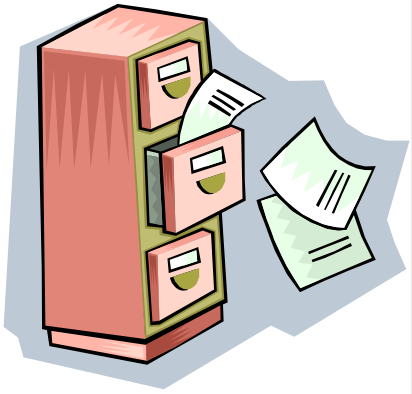

Figure 3-1 Dam owners should maintain complete project files.

A dam project file is essentially a compilation of all information pertinent to a specific dam. A thorough assessment of dam safety cannot be made without ready access to this information. Each organization may have its own guidelines concerning the structure of the dam project safety file; however, it should contain the four general types of information listed above. The

goal of the dam project file is to provide ready access to information that can be used to help prepare for conducting a dam safety inspection, evaluate the observations made during a field examination, and have pertinent information available in case of an emergency or serious problem.

Table 3-2
Recommended Information Database for Project Files

(1) Background Information	**Sources**
Dam owner & responsible parties	Regional & site geologic & seismic reports
Dam location	Logs of drill holes & test pits
Site topographic mapping	Geophysical exploration reports
Surface & subsurface geology	Project files & maps
Exploration techniques employed	Materials testing reports
Regional & site seismicity	USGS Quadrangle maps
Soil surveys and land use	County soil maps
Photographs	
Emergency Action Plan (if available)	

(2) Design Information	**Sources**
Material engineering properties	Design reports & calculations
Embankment design & materials	Technical record of design
Stability analysis & assumptions	IDNR project files
Structural design criteria	Field & laboratory test reports
Drainage area characteristics	Flood hydrology reports
Rainfall & stormwater runoff analysis	Hydraulic model reports
Design flood	Precipitation and runoff calculations
Reservoir flood routing analysis	Contract plans & specifications
Spillway and outlet hydraulic analysis & design	Dam breach flood routing analysis
Mechanical & electrical components	Geotechnical reports
Hazard potential classification	

(3) Construction Records	**Sources**
Construction procedures, methods & control	Construction specifications
Quality control test procedures & results	Daily construction inspection reports
Foundation surface characteristics & treatment	Construction progress record
Abutment surface & treatment	Quality control testing reports
Subsurface treatment & drainage control	Foundation acceptance reports
Design-related changes	Project correspondence
Final configuration of dam & foundation	As-constructed drawings & photographs
Extraordinary events during construction	Instrumentation installation reports

(4) Operational Performance Records	**Sources**
Inspection Reports	Previous operation & maintenance reports
Post-construction record floods & seismic activity	Previous inspection reports
Hydraulic performance of spillway & outlet	Special inspection reports
Structural behavior of embankment & foundation	Instrumentation records
Water retention behavior of embankment & foundation	Design operating criteria
Chronological reservoir stages	Standard operating procedures & manuals
Noteworthy spillway & outlet discharges	Materials testing reports
Repairs, alterations or modifications & reasons	Regional & site maps showing access routes
Materials deterioration descriptions	IDNR project files
Layout & performance of surveillance instrumentation	Dam owner's project files
Original instrumentation design assumptions	
Access route to the dam, spillway & outlet	
Maintenance records	
Operating procedures & records	

The project records created over the years are essential for a periodic inspection program. These records provide data that form a basis for making engineering evaluations and decisions. They provide project familiarization and orientation to inspection personnel and involved private or public agencies. The project files may also be needed for reference during emergency situations. Knowledgeable personnel familiar with a dam may be unavailable during a crisis, so information in the files may be required to help resolve problems. This source of ready reference is also needed because of personnel turnover and organizational responsibility. Seldom will an individual have been continuously involved in a project since its inception, and personnel assignments change. Collecting this diverse, project record and maintaining it as a continuing record in a permanent file is therefore essential to an effective periodic inspection program and ongoing dam maintenance. When necessary, special exploration and testing, analytical studies, and reevaluation with advanced technology may be performed to obtain necessary information for the project files and inspection efforts.

Project files should be compiled in a systematic format. A standardized, orderly, predetermined arrangement will facilitate the use of the files and accommodate future additions more readily. Generally, the project files will grow with time as new and additional information is added.

The extent of the file review will vary with the type of inspection being performed. For example, if a formal technical inspection will be conducted by a new inspector, the entire project file should be thoroughly reviewed. If an informal inspection will be performed by the dam maintenance personnel, only the previous inspection reports may need to be examined. In any case, the project files should contain a complete information database for the dam in question.

3.2.2 Types of File Review

Generally, there are three types of file review that may be performed as part of a dam safety inspection: (1) preliminary file review, (2) comprehensive file review, and (3) informal file review. The type of review will depend on the type of inspection and the inspector's familiarity with the dam.

Table 3-3
Types of File Review

Preliminary	Identify areas needing further research
Comprehensive	Thorough review of applicable files
Informal	Quick review of specific items

Preliminary File Review

A preliminary file review is an initial review of general information about the dam that will be inspected. Sufficient information is reviewed to:

- Select the appropriate records to review in detail (based on features of the dam to be inspected, geologic areas, etc.)

- Schedule the visual inspection (time of year for the desired operating condition, and the amount of time the inspection will take)
- Select members of the inspection team
- Make arrangements for operation and visual inspection of certain features

Conducting a preliminary file review involves gathering and reviewing general information about the dam to be inspected. The preliminary review gives the inspector an overall picture of the dam, and helps to identify areas which need further research and preparation.

The objectives of the preliminary data review are to:

- Identify the owner of the dam
- Identify the exact location of the dam
- Determine the type of inspection to be performed
- Identify the features to be inspected and features with noted deficiencies
- Identify upstream and downstream conditions
- Determine the timeframe for the visual inspection (time of year and amount of time the inspection will take)
- Determine extent of comprehensive review

Comprehensive File Review

A more comprehensive file review covering all features of the dam should be made after conducting a preliminary review of the file data. The amount of information reviewed and evaluated before the field examination will depend on the type of the inspection and the potential problems that may be present. A review of the entire project file should be performed for formal technical inspections. If the same inspector performs the inspections all the time, he/she may spend less time on some parts of the file, and more time on other parts. If the inspection is the first formal technical inspection for a particular inspector, he/she should review the entire file. Preparation for a maintenance inspection may include a review of applicable portions of the file only, such as operational performance records, construction records of key dam components, and design criteria related to dam spillways and outfalls. If the dam has known problems that are being monitored, that portion of the files that deals with the problem area(s) should be reviewed. Each file review should be tailored to the specific type of inspection and the potential problems that may be encountered.

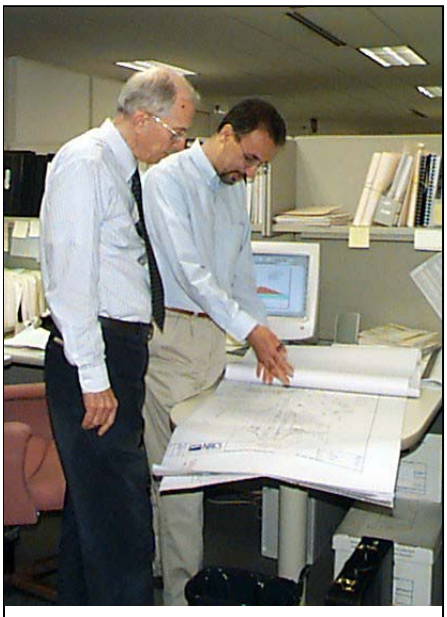

Figure 3-2 Every inspection should begin with a file review.

The objectives of a comprehensive file review are to:

- Reveal potential dam safety deficiencies that may not be visible during the field examination, and identify potential dam failure modes
- Help interpret conditions that may be observed in the field
- Help develop an inspection plan that will ensure a thorough onsite dam safety inspection

Conducting a comprehensive review of available data involves gathering and reviewing all pertinent information about the dam to be inspected. The following general criteria should be identified during the comprehensive data review:

- The type of dam to be inspected and its individual features
- The intended use of the dam and reservoir
- The underlying and surrounding geologic conditions
- Design and construction details pertinent to the safety of the dam
- Operational issues that affect performance
- Presence of instrumentation, and results of data analysis
- Conditions that might, at some point, affect the structural integrity of the dam (e.g., fault zones, lack of drainage features, alkali-aggregate reactive concrete, increasing seepage, etc.)
- Past problems with the performance or operation of the dam or any of its features that need to be addressed during the inspection
- Past problems with the foundation or abutments (during construction or operation) that need to be addressed during the inspection

If a formal technical dam safety inspection is being performed, design and construction details should be compared to current criteria or state-of-the-art to determine whether materials or procedures used at the time the dam was constructed pose a threat to the safety of the dam when compared to current standards.

Informal File Review

An informal file review consists of reviewing select parts of the dam project file in preparation of informal and special inspections. For example, the inspector may only review the previous inspection reports or report forms prior to performing an informal inspection. In some cases, the inspector may review only the project photographs. In most cases, informal reviews are made by personnel thoroughly familiar with the dam who are concerned about a specific dam feature.

3.2.3 Background Information

Background information includes general information and data that define the dam and its environment. This information is generally used to become familiar with the type of

dam, its location, and important features or concerns. The following list summarizes the background information that should be included in the project files.

- Dam owner & responsible parties
- Dam location
- Site topographic mapping
- USGS Quadrangle maps
- Surface & subsurface geology
- Site geology reports
- Exploration techniques employed
- Regional & site seismicity
- Underground mine maps
- Soil surveys and land use
- Aerial and site photographs
- Correspondence
- Emergency Action Plan
- Expert consultant reviews
- History of site before construction

Figure 3-3 Aerial photograph of a dam and reservoir in Indiana.

Over time, situations or conditions may be created upstream or downstream of a dam that have an effect on the dam and the reservoir. Examples of upstream conditions that could affect the dam are the construction of another dam or a water conveyance system, or the construction of a new housing subdivision. A downstream condition might be development in the floodplain that would change the dam's hazard classification. The inspector should try to identify any new conditions or changes in existing conditions prior to conducting the field examination.

Part 2 of the Indiana Dam Safety Inspection Manual contains a detailed discussion of the geological setting of dams. Included with the discussion is a physiographic map of Indiana that shows regional geologic conditions and a table that helps define potential conditions which may be present at the project site. This information can be useful for evaluating dam seeps, foundation, or settlement issues and should be checked before the field inspection is performed.

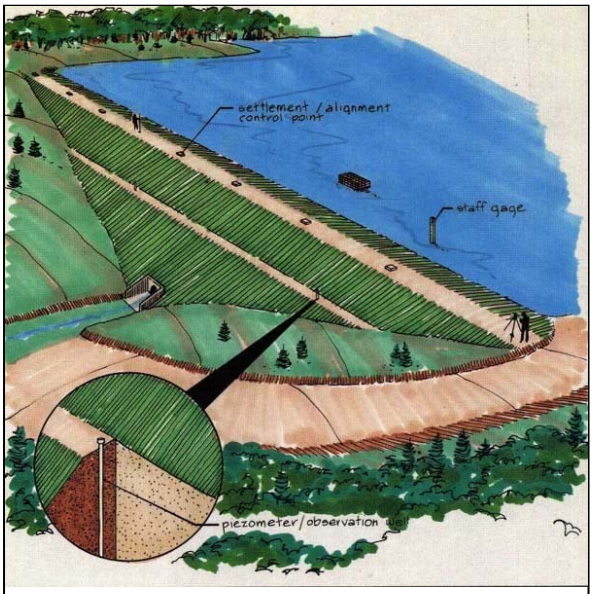

Figure 3-4 A dam sketch showing instrumentation points.

3.2.4 Design Information

Design information for dams varies widely in form and detail. Records may be found in the form of simple pencil sketches with brief notations on the dimensions, or as detailed plans and specifications along with

complete design and geotechnical reports. The availability of the design documents for review will depend on the completeness of the records kept by the owner, design agency, engineering firm, and regulatory office.

The dam project file should also be carefully reviewed for any documented modifications to the original design. The inspecting personnel must be able to verify structural elevations and dimensions, locations and sizes of appurtenances, and variances from the original design. Design changes, including items which may have been deleted during construction, must also be identified. As-built drawings should be reviewed when available.

Table 3-4
Recommended Design Information in Project File

(1) Design Plans	Location map, site plan, project elements, elevations, materials of construction, sizes of structures, dam hazard classification
(2) As-Built Plans	Actual constructed sizes, locations, modifications, elevations, etc.
(3) Construction Specifications	Materials, general and special procedures, testing procedures and requirements, size and strength requirements
(4) Design Reports	Hydrologic analysis, drainage area characteristics, hydraulic calculations, embankment design, spillway and outlet design, mechanical and electrical component design, stability analysis, seepage studies, settlement analysis, seismic analysis, flood routings, structural design calculations, instrumentation design
(5) Design Calculation Summaries	Supporting calculations with references to engineering methods and standards used in design
(6) Geotechnical/Geologic Reports	Subsurface investigations, boring logs, soil and rock testing results, laboratory investigations, borrow materials and locations
(7) Flood Studies	Upstream and downstream historic flood profiles near dam location, extremes and means of precipitation, historic stream flows and lake and reservoir levels
(8) Technical Journal Articles	Historic design papers
(9) Sedimentation Surveys & Reports	Watershed effects and reservoir availability

Many dams were never formally designed in the first place, so no design or technical information will be available. In the case of an initial formal technical inspection, the

review of a design may not be possible until the owner has been contacted or interviewed. The location or even the existence of design documents may not be known until this initial contact is made. Table 3-4 provides a list of design information that may be available in the project file.

Familiarity with the geotechnical aspects of the design can be gained through review of available boring logs, soil laboratory test results, seismic studies, and geophysical data. The extent to which this review is necessary will depend on the location, size, purpose, history of problems, and age of the dam. Since foundation and abutment areas cannot be visually inspected, knowledge of the geology of these areas and how any geologic problems were addressed during construction are very important. Evaluation of existing geotechnical and geologic aspects of a design may be performed best by an experienced geotechnical engineer or engineering geologist. The need for expert evaluation depends upon the purpose of the inspection, the size of the dam and its performance history.

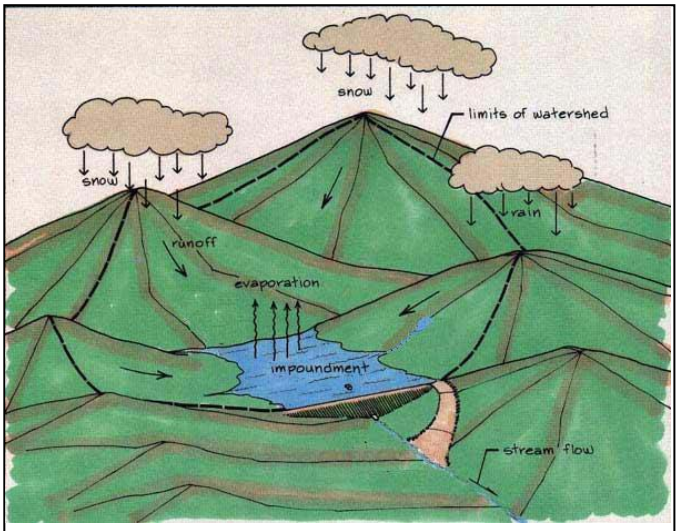

Figure 3-5 Typical hydrologic cycle.

Hydrologic information is used to design the capacities of the spillway and outlet works, and to determine how much freeboard is needed. Rainfall and runoff are important considerations when designing the hydraulic capacity of the dam and spillway structures. Over time, there may be changes to the land upstream that will affect hydrologic conditions, such as land clearing, housing developments, and other land usage. These changes could affect the amount and timing of runoff, the resulting reservoir level, and the amount and rate of spillway discharge. Therefore, during a formal technical inspection, the inspector must look at how the hydrologic design was developed and whether any conditions have changed which could affect the dam design. If the hydrologic information is dated, a hydrologist may have to reevaluate the data and methodology used to determine if changes need to be made to the dam or the spillway based upon current conditions or design standards.

The inspector should also examine downstream conditions to determine whether any changes have occurred that could affect the dam hazard classification or discharge characteristics. Construction of new buildings, houses, or other structures within the potential area of flooding could change a dam's classification from low or significant hazard to high hazard. This can impact the type and frequency of inspections that are required, as well as IDNR reporting requirements, depending on current regulations.

3.2.5 Construction Records

Construction records depict the quantities and types of materials used, variances from design plans and specifications, and any unusual geologic or other conditions encountered. Quality control efforts that were employed during construction may also be available, along with field and laboratory testing results for the dam materials. Remedial actions to correct significant problems which developed during construction, such as removal of unsuitable foundation soils, may have required the preparation of supplemental plans, specifications, and other project documents. Alterations to plans and specifications may be documented in many different forms including inspector's reports, letters, diaries, meeting minutes, special investigation reports, photographs, plan revisions, and specification alternates. Unfortunately, such alterations may or may not appear on as-built drawings. Complete omission of a design item during construction is also not unusual.

Figure 3-6 Construction photograph of embankment.

Sampling and testing records of the soil used in embankment construction are critical to understanding the stability and seepage potential of embankment dams. This information is often collected during construction and enclosed in the construction documentation report. Embankment soil density and moisture sampling and testing are two of the most commonly obtained construction parameters. Control of these two properties and compaction lift thickness is critical to embankment construction. Soil particle size determinations and soil classification are two more parameters commonly monitored during construction. Complete project files should contain information on these important soil properties.

Progress and inspector's reports will record the seasons through which construction was performed as well as document weather, construction equipment, material sampling and testing, and site conditions. When performing the inspection, this information can assist in evaluating any newly observed or previously known condition at a dam. For example, temperature extremes and dry or wet conditions, which occurred during construction, may have a direct correlation to dam seepage or

Figure 3-7 Installation of a riser pipe during winter weather.

settlement problems. Project engineers, technicians, the dam owner, and the contractor may need to be interviewed to obtain information about the construction to fully understand an observed condition. Figure 3-7 shows a dam's riser structure being installed during cold weather conditions. Troubleshooting potential future seepage problems along the discharge pipe may be aided if such photographs are available in the dam owner's project files.

The geotechnical aspects of a design may change during construction due to unforeseen foundation and abutment conditions such as the presence of a weak or fractured rock zone, or an underlying porous soil layer. Unexpected effects of excavations, blasting, and other alterations on the ground water and hillside slope stability may have been documented in the construction records along with the corrective or mitigative actions taken. When available, photographic records provide excellent documentation of construction problems and their resolution.

Construction documents will usually indicate the type of equipment used. For example, these records can help determine the degree of compaction and the rate of construction. The number of passes a soil compactor made for each lift can be used to indicate degree of compaction. The presence or absence of special equipment such as water trucks, discs, or scarifiers could provide clues to the in-place condition of constructed materials. The type of soil compactor used should be described, including the type of machine, size or weight class, and the length of the compactor pad feet. It is equally important to determine the types of equipment used in concrete construction such as transit-mix concrete trucks, on-site batch plants, cranes, conveyors, and pumps. It is important to know the type of equipment used to install discharge conduits.

Foundation and abutment preparation is a critical construction task that should be well documented with written records, maps, and photographs. All vegetative and other organic material should have been removed and replaced with suitable, recompacted soil. Records of key trench excavation, abutment preparation, backfilling, and compactive effort can be helpful with troubleshooting foundation drainage issues.

The preparation of the spillway subgrade, especially spillway conduits, should be documented during construction. The type of bedding used, the compaction efforts, and the method of backfilling conduit trenches can have a significant impact on the prevention of seepage. Methods of conduit placement and joint sealing are also important issues that can help understand subsequent problems that may develop.

Specific techniques or methods of construction that were used may have been documented. Hydraulic fills and mine tailings or coal refuse embankments are examples of dams constructed using special methods. Hydraulic fill dams may be more susceptible to seismic forces. Construction of dams with hydraulic fills, mine tailings, and coal refuse are not recommended and should be avoided. These types of structures can be impaired with both stability and environmental issues.

A critical time in the history of any dam is the first filling of the reservoir. Although

construction may be complete by this time, the reservoir filling may be documented in construction records. Observations of seepage, cracks and other conditions which appeared after the dam began impounding water may be included in these records.

Figure 3-8 Loose fill inappropriately added to embankment slope.

Alterations or modifications may occur to a dam at any time after construction is completed. In some cases, an older structure such as a wood crib dam may have been reconstructed by adding earthfill or concrete, completely covering the original dam. Additional soil fill may have been placed on embankment dams to reduce the slopes or to repair defects such as settlement or erosion. Spillways may have been replaced or upgraded if the original structures were deteriorating or damaged. The design and construction records of these subsequent changes, and whether they followed applicable agency requirements, should be reviewed, if available. Dam owners should beware of performing un-designed and un-permitted modifications to their structures. Such modifications can subject the owner to potential legal and liability issues, and could result in regulatory fines, damage payments to downstream property owner's, or prison when lives are lost if the dam fails as a result of the modifications. The inspector should note any unapproved modifications in the inspection report or IDNR Inspection Report Form.

3.2.6 Operational Performance Records

Instrumentation data will likely be the least available information for most dams. Many smaller dams will not have any instrumentation. The purpose and types of instrumentation that does exist should be familiar to the inspection team. Table 3-5 lists typical instrumentation used to monitor dams. Systems for monitoring the performance of a dam can be very complex or very simple. The more complex systems require experienced personnel to retrieve and evaluate readings and measurements. Even If they do not possess this expertise, inspecting personnel should still be aware of the location, design, and purpose of any monitoring devices to evaluate their physical condition.

All available operation, maintenance, and inspection records maintained by an owner, regulatory agency, or other entity should be reviewed. Operation records should include any previous monitoring data. Records may be reviewed before, during, or after the inspection, depending on availability and the field inspection findings.

Data collected from instrumentation and monitoring systems should be stored in the

files and kept indefinitely, unless qualified technical personnel indicate otherwise. Available monitoring records should be checked for location, type of instrumentation, method of data collection, purpose of instrumentation, and type of data collected. Records may apply to instrumentation added to a dam before it was constructed or after it was constructed. Instrumentation installed after construction is usually done to monitor a specific problem which was not apparent during the original design, or which developed after the reservoir filling is complete.

Table 3-5

Type of Dam Instrumentation

Piezometers - Pneumatic - Hydraulic - Diaphragm - Open standpipe	Measure ground-water levels and pore pressures in foundations and embankments
Horizontal & Vertical Movement Devices - Surface monuments - Settlement gages - Extensometers - Inclinometers	Measure horizontal and/or vertical movement in foundations, embankments, and appurtenances
Seismic Instruments	Measurement of earth motion
Weirs, Flow Measuring Devices	Measurement of seepage, water releases
Concrete Structures - Strain/Deflection - Joint/Crack Movement - Stress/Pressure/Uplift - Water Leakage - Plumb Lines and Tilt - Alignment - Seismic Instruments - Temperature	Devices for determining stresses and movements of a concrete structure with respect to allowable tolerances
Pool & tailwater level gages - Staff gages - Pressure gage - Riser markings	Measurement of water levels/elevations

3.2.7 SOURCES OF INFORMATION

The information sources for a specific dam may be in several locations, depending upon the developmental history of the project, previous file maintenance techniques, personnel involved with the dam, and any ownership changes.

Records for dams constructed with the Natural Resource Conservation Service (NRCS, formerly the Soil Conservation Service) or IDNR assistance may be found in the active files and archives of those agencies. If design or other engineering services were provided by other Federal agencies such as the Bureau of Reclamation (now the Water and Power Resources Service) or the U.S. Army Corps of Engineers (USACE), records may be located in the archives of those agencies. Engineering firms that have been

involved with the dam should have project files concerning the work they performed. IDNR has conducted regulatory dam safety inspections on all dams known to be within the agency jurisdiction. If dams of interest or concern to the NRCS or the U.S. Forest Service are or have been under the jurisdiction of a state agency, data sources may be in their files.

In some instances, information might be obtained from the files of the contractor who constructed the dam, but it will likely be of limited extent and value. However, the possibility of obtaining photographs should not be overlooked.

Newspaper accounts will sometimes provide helpful information, especially during periods of sensational events such as large floods or earthquakes. While reliable facts and engineering considerations will seldom be obtained from such accounts, useful photographs may have been taken.

If the dam is noteworthy or unusual, engineering and construction contracting periodicals may have published some dependable data concerning its design and construction. Reliable accounts of dams constructed many years ago will sometimes appear in old engineering periodicals. Journals and technical publications of engineering associations such as the American Society of Civil Engineers and the United States Committee on Large Dams often contain reliable data on dams. However, such data are usually available only for large, notable dams.

Table 3-6
Sources of Information

Construction Documentation Records
Design Reports & Calculations
Slides/Photographs/Newspaper Articles/Other Publications
Precipitation Records & Observations
Lake/Reservoir Levels & Observations
Dam Safety Inspection Reports
Operation Reports
Routine Maintenance Records
Routine Equipment & Gate Operations Records
Instrumentation Readings
Dam Repairs & Equipment Rehabilitation Records
Regulatory Agency Reports & Permits
- State (DNR)
- Local Energy Regulatory Commission (FERC)
- Environmental Protection Agency (EPA)
- U S. Army Corps of Engineers (USACE)
- U.S. Bureau Of Reclamation (USBR)
- U.S. Department of Agriculture (USDA)
- U.S. Geological Survey (USGS)
- Natural Resources Conservation Service (NRCS)
- National Databases

Sedimentation Surveys
Inspection Reports (Owner, Regulatory Agency, Consultant, Others)
Regional & Site Geologic & Seismic Reports
Logs of Drill Holes & Test Pits
Geophysical Exploration Reports
Project Files & Maps
Materials Testing Reports
USGS Quadrangle Maps
County Soil Maps
Field & Laboratory Test Reports
Contract Plans & Specifications
Geotechnical Reports
Project Correspondence

Interviews with persons associated with the project during its construction and subsequent operation can sometimes provide answers to specific questions. Such persons may include contractors' representatives, individual workmen, owners, owners' engineers, operation and maintenance personnel, IDNR representatives, and members of the general public. Responses obtained by such interviews must be carefully screened and evaluated, considering the involvement and background of each person.

The records and files for existing dams vary considerably in completeness, quality, and

usefulness. Their existence and character will vary with the age of the facilities, the type of ownership, and the project engineer, if there was one. In many cases, records (especially of design and construction) may be totally nonexistent, fragmentary, or inaccurate. It is important, however, that a diligent search be made for all records, because the information therein may be vital and unavailable from any other source (e.g., treatment of unusual or difficult foundations). Available data relating to the general area around the dam and reservoir should also be reviewed.

3.3 INSPECTION FIELD KIT

A wide range of equipment may be required by the team to satisfactorily perform the safety inspection. The equipment needs depend on many parameters such as weather conditions, type of dam, complexity of design, condition of the dam, instrumentation, and purpose of the inspection. Below is a listing of general equipment, specialized equipment, and safety equipment and protective clothing which may be useful to the inspection team.

Figure 3-9 A typical inspection field kit.

Equipment should be maintained properly and stored securely when not in use. Instruments should be adjusted properly, inspected often, and calibrated regularly. Misplaced or damaged equipment can reduce the effectiveness of or even alter the outcome of the inspection. Personal equipment items include clipboards, field notebooks, pencils, pocket rulers, proper clothing, and pocket knives. Also, a reduced copy of the drawings for the dam being inspected is a convenient means to have design data readily available during the inspection.

General Inspection Equipment

Inspection Checklist - Serves as a reminder to inspect for all important conditions. An example is presented in Appendix B.

General Embankment Sketch - A sketch of a typical dam embankment may be used to denote the location and dimensions of deficiencies on the embankment and abutments of the dam. A ruler may be useful for scaling dimensions on the sketch.

Notebook And Pencil - It is very important to write down observations at the time they are made. This reduces mistakes and the need to return to the area to refresh the inspector's memory. A clipboard can provide a sturdy writing surface.

Tape Recorder - A small portable tape recorder can be used effectively to make a record of field observations when it is not convenient to make written notes.

Camera - Photographs provide a reliable record of observed field conditions. They can be valuable in comparing past and present configurations. An inexpensive model usually takes pictures good enough for inspection records. Modern digital cameras are excellent for the development of comprehensive photographic records.

Hand Level - This is needed to locate accurately areas of interest and to determine embankment heights and slopes. A **surveying rod** (stadia rod) or other type of measuring rod is a useful aid in determining measurements.

Probe - A probe can provide information on conditions below the surface, such as the depth and softness of a saturated area. Also, by observing moisture brought up on the probe's surface, the inspector can decide whether an area is saturated or simply moist. Probes with a metal tip are preferred. An effective and inexpensive probe can be made by removing the head from a golf club.

Tape Measure - Many descriptions are not accurate enough when estimated or paced. The tape measure provides accurate measurements which allow meaningful comparisons to be made.

Flashlight - The interior of an outlet in a dam can often be inspected adequately without crawling through by using a good flashlight or fluorescent lantern.

Shovel - A long-handled shovel is useful in clearing drain outfalls, removing debris, and locating monitoring points. A short-handled shovel may suffice and is more convenient to carry.

Rock Hammer - Questionable-looking riprap or concrete can be checked for soundness with a rock hammer. Care must be taken not to break through thin spots or cause unnecessary damage.

Bonker - The condition of support material behind concrete or asphalt faced dams cannot be determined by observing the surface of facing. By firmly tapping the surface or the facing material, conditions below can be determined by the sound produced when the material is tapped. Facing material fully supported by fill material produces a "click" or "bink" sound, while facing material that is over a void or hole in the facing produces a "clonk" or "bonk" sound. The bonker can be made of 1 ¼ inch hard wood dowel with a metal tip firmly affixed to the tapping end. A rubber shoe like those on some furniture legs is recommended for the other end to allow the bonker to be used as a walking aid on steep, slippery slopes.

Binoculars - These are useful for inspecting limited access areas especially on concrete dams. They are also useful for inspecting risers and trash racks that are not accessible from the dam embankment.

Bucket and Timer - These are used to make approximate measurements of seepage or leakage flows. Establishing the time it takes the seepage flow to fill the bucket

enables the inspector to calculate the number of gallons per minute. Various container sizes may be required, depending on the flow rates. More accurate measurements can be made with a flow meter when the discharges are relatively large.

Stakes and Flagging Tape - These are used to mark areas requiring future attention and to stake the limits of existing conditions, such as cracks and wet areas, to allow future comparison.

Knife or Machete - These tools can be useful for clearing weeds and brush, and for scraping rocks or soil.

First-Aid Kit - A basic first-aid kit should be part of every dam inspection kit in case of injury. At a minimum, it should include assorted bandages, anti-septic medicine, pain relief tablets, sunburn lotion, ice packs, a splint, sterilized gauze, scissors, tweezers, and sterilized tape.

Specialized Equipment

Video Camera - A video camera, preferably digital, can be used to record the entire site; this may be particularly helpful for concrete dams or spillways where access is difficult. A high-power magnification can be very useful when videotaping concrete dams. Most video cameras are also equipped with sound and date recorders.

Inclinometer - An inclinometer is used to make quick measurements of embankment slopes.

Flow Meter - This instrument is used to measure flow velocity and quantity. The flow must be relatively large; small seeps can not be measured with a flow meter.

TV Monitor - A TV monitor is used to view and record conditions inside pipes and conduits that are inspected with a video camera mounted on a remote control vehicle.

Two-way Radios - These are useful for communications when more than one inspector is present on relatively large sites.

Confined Space Access Equipment - This includes equipment for personnel access to vertical risers, discharge conduits, etc, where emergency retrieval may be necessary. This includes such things as ropes, harnesses, and ladders. It also includes portable gas meters for testing confined spaces for harmful gases that may be present. These may be required when entering discharge structures under the ground.

Boats - A boat may be required for access to areas on the reservoir, including shorelines and spillways.

Piezometer Gage or Water Level Indicator - Used to measure depth to water in piezometer wells.

Pocket PC's and Laptop Computers - These portable computers are a convenient tool for making field inspections cost effective and efficient. The computers must have software that is designed for dam inspections, and must be compatible with other office equipment so that the information can be readily transferred to the inspection report. Pocket PC's are often referred to as "PDA's."

Safety Equipment and Protective Clothing

Hard Hat - A hard hat is recommended for inspecting large outlets or when working in construction areas.

Rope - Can be used when inspecting steep slopes or conduits. A rope can also be used when inspecting areas along the shoreline. Generally another person should be present to assist with the use of a rope.

Bug Repellent - Biting bugs can gravely reduce the efficiency and effectiveness of the inspector and sour his disposition. Ticks and mosquitoes can cause skin irritations and severe health problems in some instances.

Snake Bite Kit - In areas where rattlesnakes or copperheads might be present, a snake bite kit should be included in the first-aid kit; protective leg guards are also available.

Watertight Boots - These are often required when inspecting various areas of the dam site where standing water is present. Waist-high waders are useful for riser inspection.

Steel-toed Shoes - Steel-toed shoes should be used when there is a danger of debris falling on the inspector's feet.

Sturdy Hiking Boots - Hiking boots may help prevent slipping and falling when traversing slopes and wet areas. Good ankle support can aid in preventing injury to ankles.

Life Jacket - A life jacket is a good idea for inspecting areas where there is a danger of falling into the water, especially along the shoreline of a deep reservoir, or a reservoir with steep upstream slopes. They are a necessity if the inspector is using a boat.

Cellular Telephone - A cell phone can come in handy in emergencies or when additional information is needed from the office or the owner's office.

Safety Glasses - May be required in some cases for eye protection.

Gloves - May be useful if stakes are being installed, or if riprap and deteriorated concrete is being investigated.

Orange Vest or Coat - If inspections are performed during hunting seasons, bright colored clothing is a good preventative measure to avoid shooting accidents.

3.4 INSPECTION SCHEDULING

Inspection scheduling is dependent on numerous factors, such as who will be present, where the dam is located, the type of inspection, the time of year, and the condition of the dam. All individuals who are to attend the inspection must be notified of the date, time, and location. The scheduled time and date will need to accommodate everyone's personal schedule. Coordination with state and federal agencies, local government officials, industrial owner representatives, engineering consultants, and individual private owners may be necessary. Representatives of divisions or sections internal or companion to the regulatory dam safety agency may need to be included. If an interview with the owner, operator, or other individual is to be conducted separately, the meeting location and time should be established appropriately. In setting the time for the inspection, time zone changes, and travel times for all parties should be considered. The amount of vegetation on the embankment and the level of water in the reservoir or spillway can also have a direct impact on inspection scheduling.

The dam owner or operating personnel should be notified in advance if they will be asked to assist in the inspection. For example, areas may need to be dewatered or equipment may need to be operated. Drawdown equipment should be checked at least once per year to make sure it is working properly. Also, arrangements for gate or door keys, transportation, and special equipment should be made ahead of the inspection.

There are two principal criteria for determining the general time frame for a dam safety inspection: the time of year (or season) in which the inspection will take place, and the time it will take to perform the actual inspection. After the general time frame is established, the specific day and time of day can be scheduled.

Table 3-7
Things to Consider when Scheduling Inspections

Weather and seasonal conditions
Amount of vegetation present
Dewatering outlets, spillways, and stilling basins
Special equipment needs and availability
Planned aerial photography
Reservoir level
Recent seismic or precipitation events
Owner/operator requests
Agency-mandated inspections
Type of inspections
Underwater inspections
Inspection team members
Availability of inspector(s)
Travel distance to dam
Inspection safety concerns
Existing litigation

If many or all of the features of the dam will be inspected, the time of year or season in which the inspection will take place can be important. The inspection may need to be performed when the reservoir is at its lowest point or after a large release of water so that those features or areas of the dam that are normally under water are exposed. Also, removal from service and inspection of some features may be possible during periods of limited operational requirements. If the inspection requires that certain features be tested or inspected as close to full design load as possible (i.e., maximum reservoir elevation), the inspection may need to occur when the

dam is at its normal yearly maximum elevation. This may also allow the inspector to observe equipment as it operates under maximum design loading conditions.

Inspector safety and convenience may play an important role when scheduling a visual inspection. While a dam should be accessible any time of the year for inspections, if the embankment area is heavily vegetated it may be best to inspect the dam when the vegetation is dormant (late fall, winter, or early spring). This may make it easier to locate settlement, cracks, or animal burrows. Overgrown vegetation is inappropriate for any dam and should not be present to hinder inspection; however, in reality there are dams that do have inappropriate vegetative growth. If snakes are present at the site, the inspection may be scheduled for those periods when the snakes are inactive (cool weather months). Insect presence (bees, ticks) may also be a determining factor for scheduling an inspection. Inspecting a dam when it is raining, snowing, or extremely cold or hot could pose specific health and safety concerns for some inspectors.

Existing litigation issues may hinder dam inspection if the dam files are “frozen” or if site visits are prohibited under court order. In some cases, visitors are not permitted at the dam site unless officers of the court accompany the inspector.

Consideration should also be given to the time it will take to perform the inspection. A comprehensive visual inspection could take a full day or more than one day and additional travel arrangements may be necessary. In some cases, it may be desirable to return to view an identified problem area under different weather conditions or other circumstances. Return visits and inspections extending more than one day may not require the presence of all parties, who should be so advised. After it has been determined what features of the dam will be inspected as well as the general scope of the project, review of the records of past inspections may reveal how long the inspection will take. Experience will also aid in judging the length of inspections.

In summary, the amount of time the dam safety visual inspection will take is dependent on the following factors:

- The size and complexity of upstream and downstream areas to be visited
- The type of inspection being conducted (e.g., an initial, formal technical dam safety inspection will take longer than a special inspection)
- The number and complexity of appurtenances to be inspected
- Whether the inspection requires operation of drawdown or spillway structures
- The size of the structure. If the dam is a very long embankment dam, it will take considerable time to walk and inspect all the features (to inspect the upstream slope, downstream slope, and crest). If it is a large concrete dam, it may have numerous galleries.
- The size of the inspection team
- The condition of the dam and its appurtenant works. Dams in generally poor condition may require significantly more time to observe and document the conditions.
- Dams inspected during inclement weather generally will require more time.

- Underwater inspections and conduit TV recordings will take considerable time.
- Whether the reservoir will be inspected in addition to the dam, and what method of inspection will be used.
- The location of the dam. Dams that are located a considerable distance from the inspector's office will require significant travel time.
- Unknown, unexpected conditions

3.5 INSPECTOR SAFETY

The inspector should be aware of and plan for potentially hazardous site conditions that may be commonly found at dams. Inspectors should use appropriate safety gear and clothing when needed, and should always use extreme caution when performing visual inspections of dam spillways, embankments, riprap areas, and shorelines. Potentially dangerous areas and hazards include steep or wet embankment slopes, spillways with high sidewalls or flowing water, spillway conduits, confined spaces, riprap areas with large stones, outlet structures containing water, shorelines with riprap and deep water, concrete embankments, sinkholes, outlet banks, and high grass or bushes. Some of the dangers presented by these features include slipping, falling, drowning, tripping, lack of oxygen or presence of noxious gases, stepping in holes, snakes, and bee stings.

Low head dams constructed across streams and rivers also present a safety hazard in the area immediately downstream of the dam. The whirlpools, hydraulic jumps, and eddies created from the discharging water are extremely dangerous to boaters and swimmers, and there have been many drowning accidents that have occurred in such areas. It can be very difficult or impossible for swimmers and boats to escape from this area, especially during periods of increased flow following precipitation events. For this reason, these dams are often referred to as "drowning machines."

Some dams are located in remote areas where illegal activities may be conducted by people living in the area (such as drug labs or drug cultivation). In this case, intruders, such as dam inspectors, may not be welcome and may be in danger of physical harm by the people performing the illegal activities.

If a site has known safety hazards, it is essential that the visual inspection be conducted by more than one individual.

3.6 CONTACTING THE OWNER

The dam owner or operating personnel should be notified in advance if they will be asked to assist in the inspection. Interviews with the owner, operator, owner's engineer, project personnel, and others may be conducted before, during, or after the inspection. A formalized interview and records review form is an excellent way to ensure that pertinent questions and information are not overlooked. Previously unavailable files, operation and maintenance records, emergency action plans, and other records can be

reviewed. If the interviews are conducted before the inspection, the team can determine if there are any specific areas that should be examined. Questions about the dam can be clarified, possibly adding better understanding of the dam's design, construction, and past performance. The inspection team can evaluate the adequacy of the owner's or operator's records and then advise the owner or operator on ways to improve the documentation and project files.

Review of records will provide the inspection team an opportunity to discuss normal operation procedures with the owner or operator. Although information may have been available about previous dam operation, current procedures may have changed. Special operations such as a reservoir drawdown or water releases may be revealed. The inspection team may also check their visual observations against the owner's records after the inspection.

The dam owner or his representative should be present during the field examination. If they are not present, the inspector should contact the dam owner or his representative after the inspection is performed to discuss the results. The inspector (or inspection team) should brief the owner or operator on the preliminary findings, clarify any questions, make suggestions about record keeping, updating the Emergency Action Plan (if one exists), operations, or monitoring, and explain any follow-up activities that may be required.

The inspector should also educate the owner on all issues relevant to dam safety, including how the deficiencies that are observed could progress and lead to a potential failure situation. Potential dam failure modes should be discussed so that the owner understands how his/her dam could fail and under what conditions. The inspector should also provide any training tips that may help the dam owner spot and correct deficiencies, as well as how the deficiencies develop (i.e., what causes them to occur).